CHARACTERIZATION LAB

Experiment: 3
Characterization of CS amplifier

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Aim

The aims of the experiment are:

1. To determine the DC characteristics of NMOS transistor.
2. To determine the gain and frequency response of CS amplifier.

Theory

MOS is the first choice in integrated circuits because of their very low power consumption. This is in spite of the fact that they have low. MOS is used as both switch as well as amplifier. The common source topology takes input at the gate terminal and gives output at the drain terminal.
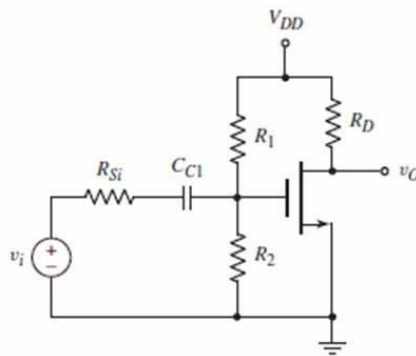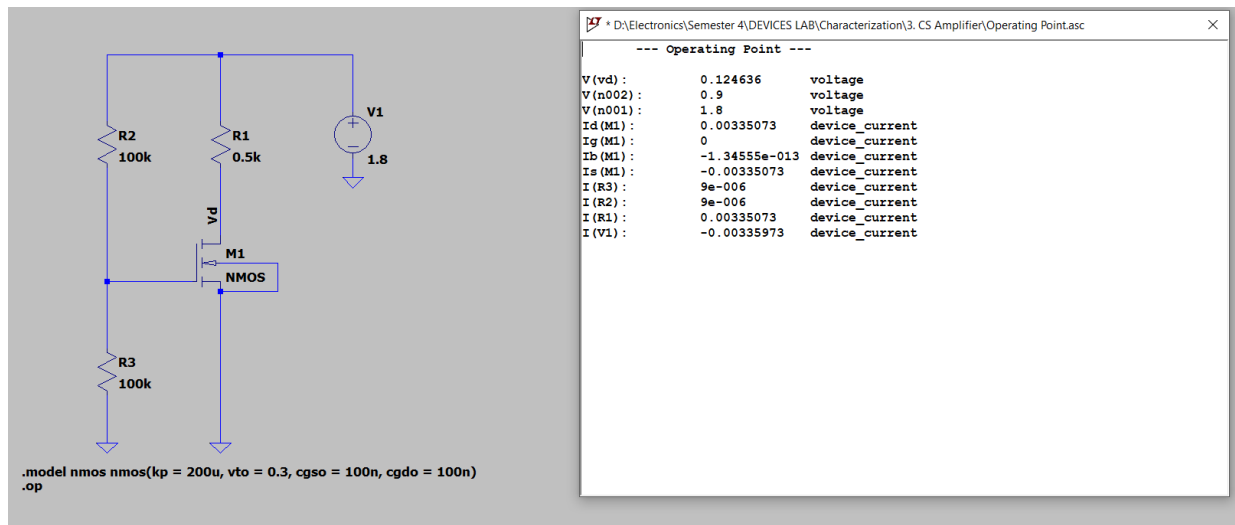

Observations and Calculations

1. DC characteristics: Plot I_{DS} vs V_{DS}. Plot for five different values of V_{GS}: V_{GS} = 0.6V, 0.9V,1.2V, 1.5V and 1.8V.
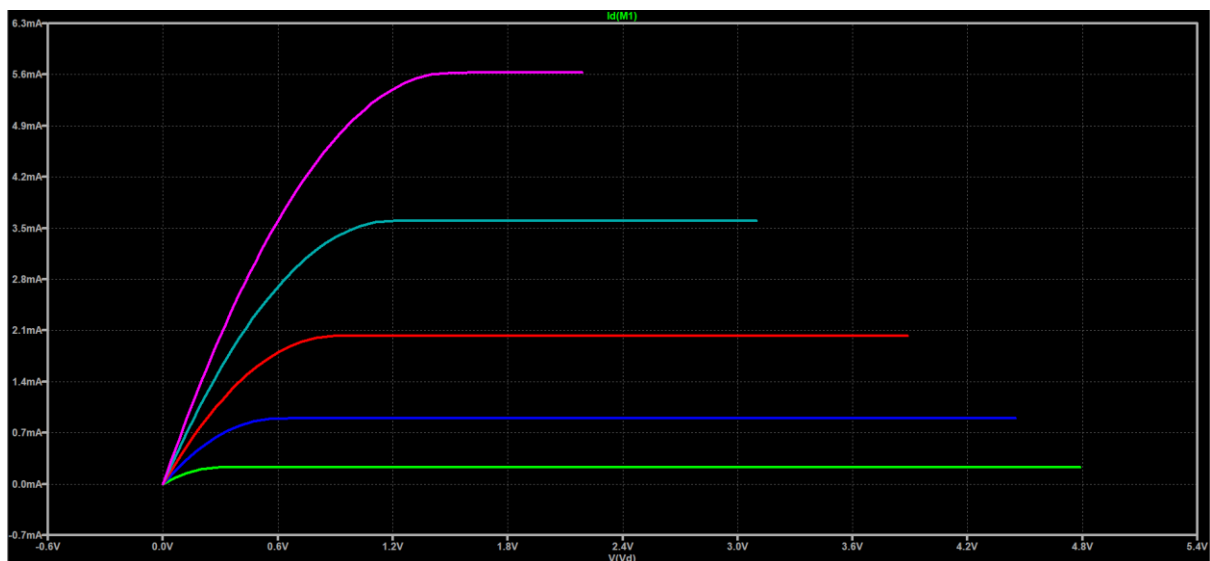
2. **DC operating Point: Find the DC operating point and check whether the circuit is in saturation or not.**


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--- Operating Point ---
V(vd):        0.124636        voltage
V(n002):      0.9             voltage
V(n001):      1.8             voltage
Id(M1):       0.00335073      device_current
Ig(M1):       0               device_current
Ib(M1):       -1.34555e-013   device_current
Is(M1):       -0.00335073     device_current
I(R3):        9e-006          device_current
I(R2):        9e-006          device_current
I(R1):        0.00335073      device_current
I(V1):        -0.00335973     device_current
```

From the results of dc operating point, we see that the transistor is in linear or triode region. It is not in saturation.
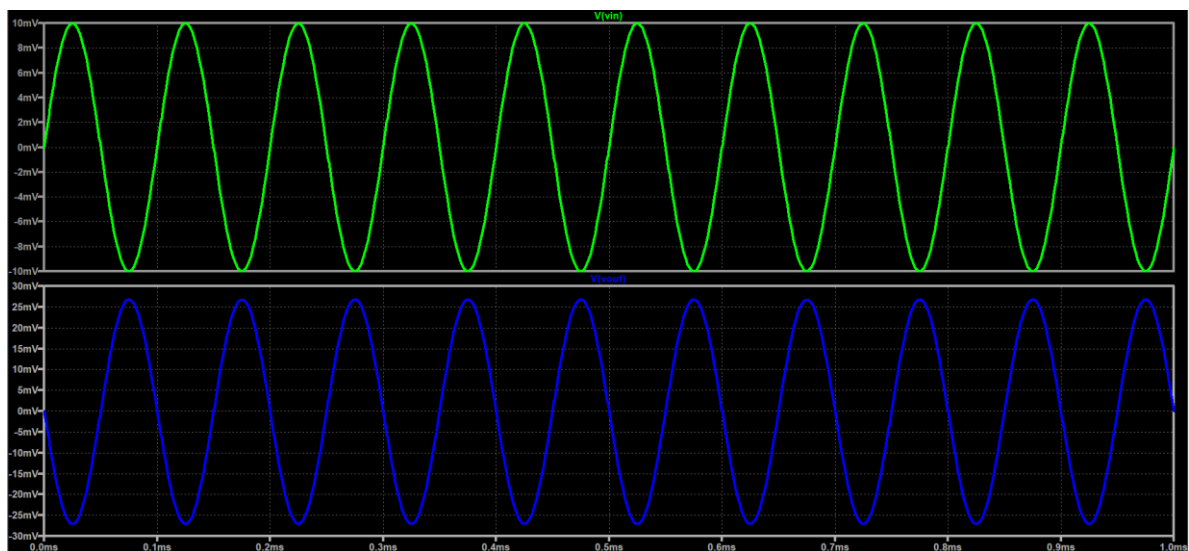
3. **Common Source Amplifier**
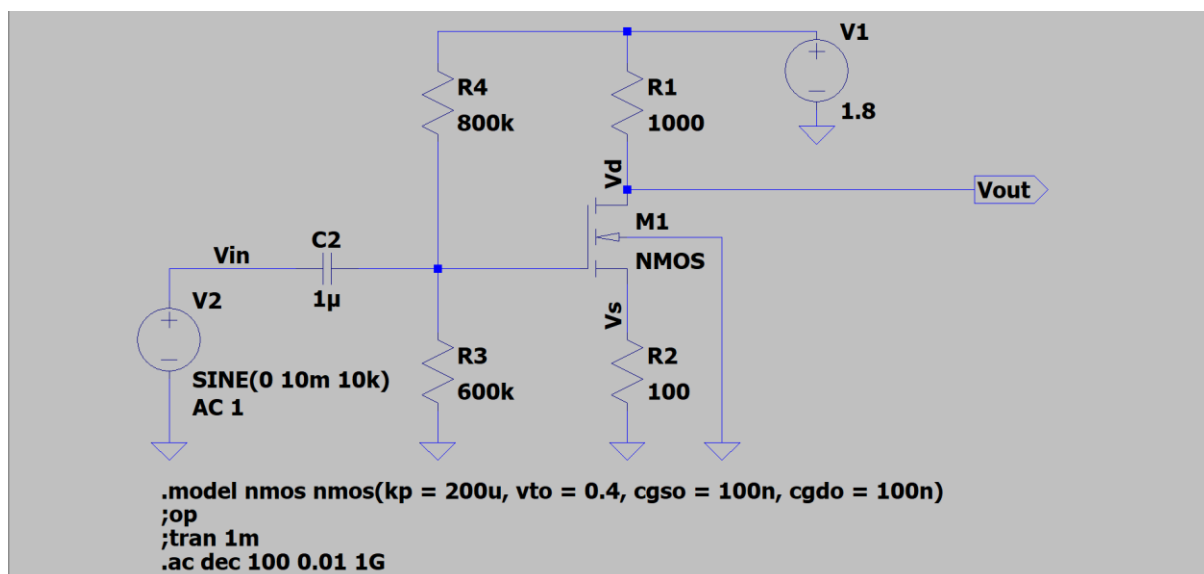
i. Apply sine wave (20mVpp, 10 kHz) through a capacitor 0.1 µF. Plot input and output signal with respect to time. Output is measured at Drain of MOSFET (with and without a capacitor 0.1 µF connected at Drain of MOSFET). Take Rs=0 ohm and also Rs=100 ohm.
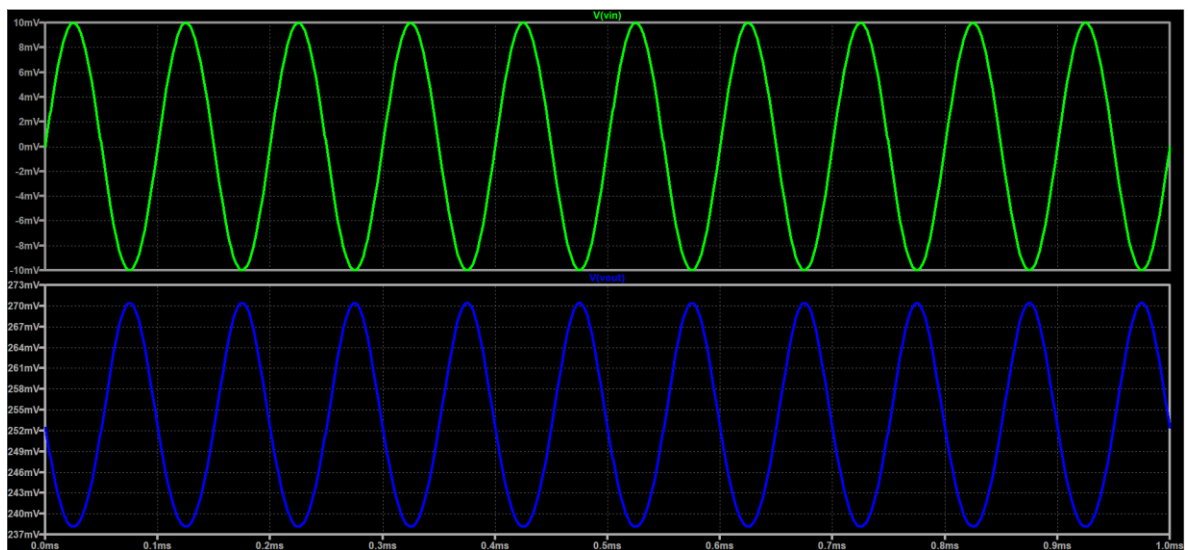
Rs = 100 Ohm and No capacitor
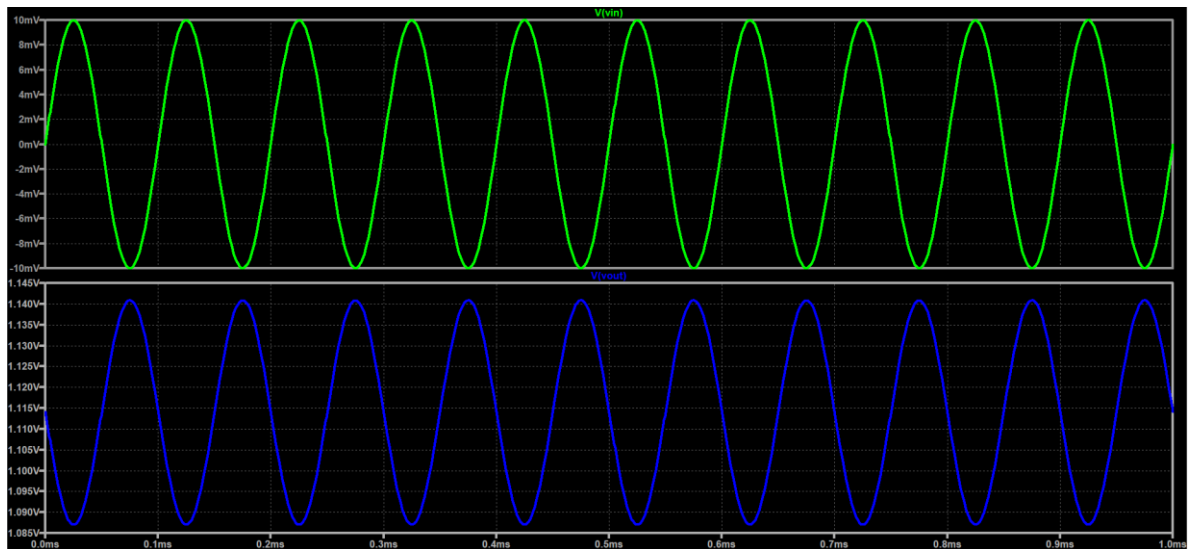
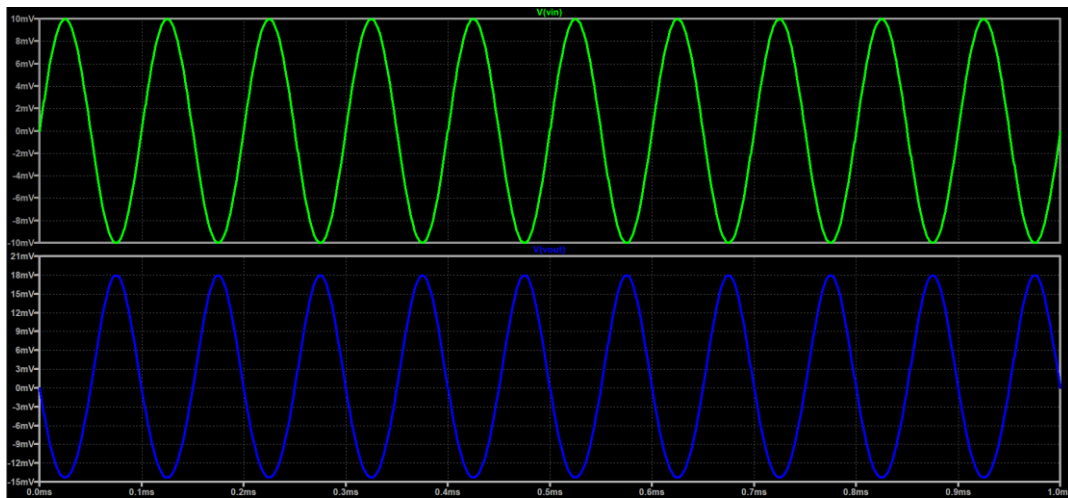Rs = 100 Ohm and capacitor

Rs = 0 Ohm and No capacitor

Rs = 0 Ohm and capacitor

ii.   Plot Gain vs Frequency, take Rs=0 ohm and find bandwidth.

The above plot shows that the -3 dB cutoff frequency is around 111.61MHz.
Since lower cutoff will be very low the bandwidth is 111.61 MHz.

iii.   Repeat the plot (ii) by changing RD = 1 kΩ, take Rs=0 ohm.

iv.   Discuss the effect of R_D and R_S on gain.

The expression for gain in terms of resistances is

$$|A_v| = \frac{R_d}{\dfrac{1}{g_m} + R_s}$$

According to the formula, the gain increases with R_d and decreases with R_s. The increase with R_d can be ascertained from the bode plot's midband gain.

Discussion

1. MOSFETs are low gain devices which is in direct contrast to BJT. This is a direct consequence of the square dependence of current on voltage as compared to BJT which has exponential dependence.
2. The CS topology is an inverting amplifier, the output and input are 180° out of phase in midband region.
3. MOSFETs have very low power consumption, is very fast in switching and can be scaled down to smaller sizes much easily than BJTs. Hence it has become the transistor of choice in modern ICs.

Result

Rd (Ohm)	Rs (Ohm)	DC Offset at output (V)	Midband Gain (dB)	Bandwidth (MHz)
500	0	0.254	4.016	111.61
500	100	1.113	8.617	16.271
1000	100	0.427	14.637	6.71